# CONFERENCE ON DISARMAMENT

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## PROGRESS REPORT TO THE CONFERENCE ON DISARMAMENT ON THE FORTY-FIFTH SESSION OF THE AD HOC GROUP OF SCIENTIFIC EXPERTS TO CONSIDER INTERNATIONAL COOPERATIVE MEASURES TO DETECT AND IDENTIFY SEISMIC EVENTS

1. The Ad Hoc Group of Scientific Experts to Consider International Cooperative Measures to Detect and Identify Seismic Events (GSE), initially established in pursuance of the decision taken by the Conference of the Committee on Disarmament on 22 July 1976, held its forty-fifth formal session from 5-15 August, 1996, in the Palais des Nations, Geneva, under the Chairmanship of Dr. Ola Dahlman of Sweden. This was the thirty-seventh session of the Group, convened under its new mandate by the decision of the Committee on Disarmament at its 48th meeting on 7 August 1979.

2. The Ad Hoc Group is open to all Member States of the Conference on Disarmament. It is also open on a standing basis to all non-Member States which have been invited upon their request by the Conference on Disarmament to participate in its work. Accordingly, scientific experts and representatives of the following Member States of the Conference on Disarmament participated in the session: Austria, Belgium, Bulgaria. Canada, China, Egypt, Finland, France, Germany, Hungary, Indonesia, Israel, Italy, Japan, Morocco, Netherlands, Norway, Pakistan, Poland, Republic of Korea, Romania, the Russian Federation, Spain, Sweden, Switzerland, Turkey, Ukraine, the United Kingdom of Great Britain and Northern Ireland and the United States of America.

3. Scientific experts and representatives from the following non-Member States of the Conference on Disarmament participated in the session: Denmark, Kazakstan and Seychelles.

4. During the session 44 papers containing information on national investigations related to the work of the Group were presented by participating experts and reviewed by the Group. In addition, substantial technical and scientific material was presented by the three GSETT-3 Working Groups on Planning, Operations and Evaluation.

5. The main topic of the session was to prepare a comprehensive Report on the GSETT-3 experiment which began full-scale operation on 1 January 1995 and is continuing. This Report is provided to the Conference on Disarmament as document CD/1422, and an executive summary is annexed to this Progress Report. The Report gives a comprehensive overview of the results and conclusions from a year and a half of GSETT-3 operation. The Report also includes specific recommendations resulting from the experiment. These recommendations could be used to facilitate a smooth and orderly transition from GSETT-3 to the envisaged International Monitoring System (IMS).

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6. The Ad Hoc Group reviewed the current status of GSETT-3, and noted that 43 primary and 90 auxiliary seismic stations in 49 countries have so far participated in the experiment. In addition, several countries have contributed in other ways, such as by providing supplementary data from their national networks, so that altogether 60 countries have participated in GSETT-3. The GSETT-3 IDC has continued its successful operation, with gradual improvement of the procedures. Data from other (non-seismic) technologies envisaged for the IMS are now gradually being integrated into the GSETT-3 IDC, using the framework originally developed for the seismic component of this experimental monitoring system.

7. The Ad Hoc Group discussed and revised a plan for GSETT-3 network calibration, an initial version of which was provided in Annex 2 to CD/1398. The Group also prepared an updated version of its recommended technical standards for IMS seismic stations. Both the calibration plan and the updated technical characteristics will now become part of the overall GSETT-3 documentation (GSE/CRP/243).

8. The Ad Hoc Group also discussed its future plans. The Group has already taken two steps toward the orderly transition from the GSETT-3 network to the proposed IMS seismic network: (1) the use of GSETT-3 stations that are not part of the proposed IMS has been discontinued in regions where the IMS network is nearly complete; and (2) attempts are continuing to encourage additional countries that have stations in the proposed IMS to join the GSETT-3 experiment. These efforts will continue.

9. The Ad Hoc Group sees the need for continued focus on improving the procedures at the GSETT-3 IDC. In particular, efforts should continue to improve and refine the automatic procedures and to reduce the need for analyst intervention in these procedures and in the correction of their results.

10. The Ad Hoc Group agrees that the GSETT-3 IDC should continue integrating data from other technologies, on a step-by-step basis, into its processing system. The resulting analyses should be reflected in the IDC bulletins so that this information, together with the raw data, will be available to experts from all IMS technologies.

11. The Ad Hoc Group noted that the on-going evaluation of GSETT-3 carried out by its Working Group on Evaluation has been one of the keys to the success of the experiment. The Ad Hoc Group intends to continue this evaluation, focusing on specific aspects of GSETT-3 that require particular attention. A list of such topics is included in the recommendations section of Annex 1.

12. The Ad Hoc Group noted with appreciation an offer from Indonesia to host an informal Regional Workshop for the Asian and Pacific regions in October 1996. This workshop will follow two similar Regional Workshops, previously reported in CD/1398, in San Juan, Argentina (November 1995) and Pretoria, South Africa (April 1996). The purpose of these workshops is to increase awareness of the GSETT-3 experiment and the future International Monitoring System of the CTBT, and to encourage the participation of countries in these regions.

13. The Ad Hoc Group expresses its appreciation to the staff at the GSETT-3 IDC and at all the national facilities around the world for their dedicated efforts which are essential in ensuring the success of GSETT-3.

14. The Ad Hoc Group recommends that GSETT-3 should continue at least through 1996 or until the envisaged Preparatory Commission for the Comprehensive Nuclear Test Ban Treaty Organization assumes responsibility, including financing, for the work on establishing the IMS. This would allow the uninterrupted operation and development of the evolving IMS, including the prototype IDC, as well as continued evaluation and calibration. In this connection, the Ad Hoc Group will hold itself in readiness, should the Conference on Disarmament request a meeting to be convened in 1997.

# ANNEX I

## Executive Summary

The Ad Hoc Group of Scientific Experts (GSE) has for the past several years developed an experimental global seismic monitoring system intended to test concepts for possible use in a future CTBT International Monitoring System (IMS). These activities, known as the GSE Third Technical Test (GSETT-3), have built upon the previous experience of the GSE and have involved the participation of 60 countries.

The GSETT-3 experiment began full-scale operations on 1 January 1995 and is continuing. This report gives a comprehensive overview of the results and conclusions from a year and a half of GSETT-3 experience. The report also includes specific recommendations resulting from the experiments. These recommendations could be used to facilitate a smooth and orderly transition from GSETT-3 to the envisaged IMS.

## Overall Concepts

The GSETT-3 experience has served to validate the viability and effectiveness of the concepts for an International Seismic Monitoring System originally specified in CD/1254. These concepts include: a single centralized International Data Center (IDC); a specifically designed high-quality seismographic network consisting of about 50 primary stations and 100-150 auxiliary stations; National Data Centers (NDCs) in participating countries; and a modern communications system to support data exchange among these elements.

Although the emphasis during GSETT-3 has been on seismic monitoring, practical experiments have demonstrated that the system design is flexible enough to incorporate the collection, processing, archiving and distribution of data from other monitoring technologies. Thus, the GSETT-3 system can provide the infrastructure needed for radionuclide, hydroacoustic and infrasound monitoring as envisaged for the IMS. In fact, these concepts are reflected in the proposed CTBT treaty text (CD/NTB/WP.330/Rev.1).

## Station network and communications

To conduct the GSETT-3 experiment, participating countries have established and operated both primary and auxiliary stations. Altogether, a total of 43 primary and 90 auxiliary stations have participated in the GSETT-3 network. The primary and auxiliary seismograph networks described in the proposed treaty text have evolved from partial networks established for the GSETT-3 experiment and on the basis of deliberations by the Ad Hoc Committee on a Nuclear Test Ban. Not all of the stations in the GSETT-3 network are included in the proposed IMS. However, at the present time, the operational GSETT-3 network includes 32 of the 50 proposed IMS primary stations and 38 of the 120 proposed IMS auxiliary stations.

The Ad Hoc Group has taken two steps toward the orderly transition from the GSETT-3 network to the proposed IMS seismic network: (1) the removal from participation

of some GSETT-3 stations that are not part of the proposed IMS; and (2) continuing attempts to encourage additional countries that have stations in the proposed IMS to join the GSETT-3 experiment (CD/1398). The participation in GSETT-3 of additional stations not envisaged for the IMS has been useful in providing temporary substitutes for IMS stations not yet available and has been essential for providing a realistic data processing load required for the development of the IDC.

The Ad Hoc Group developed technical specifications for IMS seismograph stations and tested the performance of these specifications in GSETT-3. The Group has concluded that careful attention should be given to both equipment technical specifications and to station siting considerations.

GSETT-3 has provided extensive experience in setting up and maintaining the types of communications links required for the transmission of data. These communications involve a variety of dedicated satellite, dedicated land-line circuits, microwave and radio relay links and were established on a bilateral, individual basis between the NDCs and the IDC. However, the communications arrangements for GSETT-3 were not planned and installed in an optimum manner from a cost or efficiency standpoint.

During GSETT-3, data from auxiliary seismic stations were collected using two types of communications: on-demand (dial-up) telephone lines and requests forwarded through the INTERNET computer network. Although the GSETT-3 benefited from the use of the INTERNET in terms of both cost and effectiveness on an experimental basis, there could be some concern about its use in the future treaty because of security, timeliness and reliability considerations in an operational situation.

**National Data Centers (NDCs)**

During GSETT-3, the National Data Centers have played a critical role in the operation and maintenance of reliable stations and communication links, and formed an effective interface between the GSETT-3 IDC and participating States through which data and products could be accessed and evaluated.

In addition to their main functions concerned with providing data from seismograph stations, NDCs have had an active role in the evaluation of the results of GSETT-3. Many NDCs have provided supplementary information on seismic events based on analysing data from national or regional networks. Such national contributions could be useful in the IMS, for example, in contributing to the calibration of the IMS network.

**International Data Center (IDC)**

An experimental International Data Center was established for the GSETT-3 following a lengthy and complex preparation. The GSETT-3 IDC has been in continuous operation since 1 January 1995, with only minor interruptions, acting as a data collection, processing and distribution facility for the entire GSETT-3 network. The GSETT-3 IDC performance

has improved and expanded significantly during the experiment. With only a few exceptions, the major technical problems have been solved.

GSETT-3 has demonstrated that a single IDC of the structure and size established for the experiment can successfully carry out the tasks envisaged under the IMS, including:

- acquire and archive the volume of seismic data that is anticipated for the IMS under a CTBT;
- routinely analyze this large volume of data in a timely manner;
- produce and distribute defined standard products that are useful for monitoring and system evaluation.

Many of the functions envisaged for the IMS/IDC have already been implemented in the GSETT-3 IDC. However, further improvements are needed, especially in the areas of improved redundancy and data security.

**Seismological Performance**

The seismological performance during GSETT-3 has shown steady improvement as the GSETT-3 has proceeded. Due to limited resources during GSETT-3, little effort has been devoted to new seismological concepts. Priority has been given to the production of a comprehensive daily bulletin using traditional seismological methods. The results of the performance evaluation have been documented in a comprehensive report (GSE/CRP/262) which also contains specific areas in which additional work is needed. New software designed for improving the automation and efficiency for signal detection and phase association have made significant contributions to improved performance; however, improvements in other procedures such as depth and magnitude determination, are still required.

Although a high degree of effective automatic data processing is desirable, it is recognized that review and revision (if necessary) by human analysts will always be required. Efforts should continue to improve and refine the automatic procedures and to reduce the need for analyst intervention in these procedures and in the correction of their results.

Both the detection and location capabilities of the GSETT-3 network are presently very heterogeneous. Network simulation has shown that these capabilities will be more homogeneous as the network approaches that of the IMS. Network tuning and calibration will, however, be required to achieve the detection and location capabilities expected for an operational IMS.

**Documentation**

The GSE has developed an extensive set of documentation for GSETT-3. This documentation includes a detailed description of the plan for GSETT-3, detailed instructions

for all aspects of the GSETT-3 operations, information on the facilities which are part of GSETT-3, and the procedures and results of the evaluation of the experiment. This documentation, comprising about 1,000 printed pages, is available in both hard copy and in electronic form. However, due to limited resources, the documentation is not yet complete. Also, there is a need to develop additional documentation that would be required for the future IMS operational manuals.

The GSETT-3 experience has demonstrated that such detailed documentation is essential. The electronic version of the documentation has proved especially useful, making distribution easy and making it possible to keep the information up-to-date. Major portions of the documentation have direct relevance to the documentation that will be required in the envisioned IMS operational manuals.

**Recommendations on Transition to the IMS**

Based on the extensive experience gained in carrying out GSETT-3 a number of results are emerging which could prove to be useful in establishing and operating the future IMS. These recommendations could provide guidance to achieve a smooth transition from GSETT-3 to the IMS.

**Recommended technical changes**

- There should be an orderly transition from the GSETT-3 to the IMS network, with the inclusion of stations envisaged for the IMS as they become available.
- There should be a continuous assessment of the contributions of primary and auxiliary stations and recommendations for replacements should be made as appropriate.
- There should be a complete review of the technical specifications of IMS seismograph stations drawing on the GSETT-3 experience.
- Data authentication procedures should be evaluated and implemented.
- The technical characteristics and reliability of stations and communications should be evaluated and upgraded as necessary.
- An IMS data communications concept, more cost-effective than that used in GSETT-3, needs to be established.
- More redundancy and security at all levels of the system (stations, communications, NDCs, and the IMS/IDC) is needed.
- IDC products with emphasis on functionality, reliability, and user-friendliness need to be developed.

- The IMS/IDC should develop improved testing procedures for data processing software.

- Data from other monitoring technologies should continue to be integrated into the GSETT-3 IDC system.

**Recommended improvements to seismological procedures**

- There should be continued tuning of the automatic data processing at the IMS/IDC including detection, phase identification, and phase association.

- Improved automatic consistency checks to reduce the number of false events are needed.

- Calibration of the network event location procedures, in accordance with the plan outlined by the GSE, should be carried out.

- Improvements are needed in the calculation of event locations and the specification of the associated uncertainty.

- Improved routines for data retrieval from auxiliary stations are needed.

- The methods for estimating seismic magnitudes (including Ms) should be reviewed and improved.

- Existing event depth estimation methods need to be reviewed and improved; alternative methods should be considered.

- Methods to calculate source characterization parameters should be tested and implemented.

**Recommended organisational provisions**

- GSETT-3 documentation should be developed in a form that is appropriate to serve as a complete and up-to-date operations manuals for the IMS and reference manuals for quality assurance and training purposes. The new documentation should be made available electronically, as in GSETT-3.

- The IMS should develop and implement a quality assurance plan.

- A plan for establishing an operational IMS/IDC will be required and should draw on GSETT-3 experience.

- The roles of the NDCs with respect to the IMS/IDC need to be more fully defined including in areas such as: timely and complete data accessibility, data transfer, station monitoring and maintenance, and quality assurance.

- Periodic evaluation of IMS/IDC scientific and technical procedures and products should be carried out by an independent, external panel of qualified specialists.

- A plan is needed for the training of future IMS/IDC and, as requested, NDC personnel.

- Regional workshops and other activities needed to coordinate and promote IMS activities should be pursued.